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FERTILISER SUPPLIES

ROLAND V. NORRIS

In spite of the inevitable dislocation brought about by the war it is a matter for congratulation that during 1940 there was on the whole but little difficulty in obtaining adequate supplies of fertilisers for estate use though in the latter part of the year it was found necessary to ration potash.

The position was reviewed from time to time by an informal Committee consisting of representatives of the Fertiliser Firms, the three Research Institutes, the Planters' Association of Ceylon, the Ceylon Estates Proprietary Association and the Low-Country Products Association. This Committee made recommendations in regard to the distribution of available supplies between the different industries and the utilisation of specific fertilisers. As a result each industry was, generally speaking, able to obtain the type of fertiliser most suitable to its requirements and stocks of those materials liable to be cut off were distributed equitably amongst all concerned. Moreover, by means of the voluntary scheme of rationing introduced in regard to the latter class of fertilisers, their distribution has been spread over as long a time as possible with the result that wide fluctuations in the composition and cost of mixtures have been avoided. It is a matter for satisfaction indeed that though there has inevitably been a rise in the cost of fertilisers, this has up to the present been less than might well have been expected.

Actually in 1940 imports of all three classes of fertilisers, nitrogenous, phosphoric and potassic, shewed an increase over the average figures for the previous three years. This was particularly so in the case of nitrogenous manures, some 10,900 tons of nitrogen having been imported, an increase of approximately 20 per cent over the average for the years 1937-8-9. Phosphoric acid imports were up by about 3 per cent and those of potash about 8.5 per cent. Manuring of tea estates was well maintained, and there can be little doubt that with increased prosperity in the rubber industry considerably larger quantities of fertilisers were used for rubber than had been the case previously. In short, there is every evidence that the consumption of fertilisers in 1940 reached a record figure.

Nitrogenous Manures.—Considering in more detail nitrogenous manures, while, as stated above, there was a marked increase in the total nitrogen imported, there was necessarily a considerable change in its nature. In the years 1937-8-9 ammonium sulphate provided on the average 73 per cent of the total nitrogen imported whereas in 1940 this percentage fell to about 42. This was of course due to the fact that restrictions were imposed on the export of ammonium sulphate from the United Kingdom and this material had partially to be replaced by nitrate of soda and additional imports of groundnut cake. The increasing use of the latter manure is shewn by the fact that whereas in the years 1937-8-9, organic nitrogen constituted on the average only about 17.6 per cent of the total nitrogen imported, the proportion rose to rather more than 25 per cent in 1940 and this ratio is likely to increase materially in the near future.

With regard to the use of nitrate of soda on tea estates some nervousness was at first exhibited as to possible ill-effect on the soil which it was thought might result. The Institute felt, however, able to give an assurance that such a risk was negligible, having regard to the quantities of nitrogen likely to be applied in this form and the fact that the presence of ammonium sulphate in the mixture would neutralise any harmful tendency of nitrate of soda. It is perhaps desirable to carry this recommendation a stage further in view of the fact that in the near future supplies of ammonium sulphate may no longer be available. In such circumstances the Institute would still view without alarm the use of nitrate of soda in moderate quantities, the suggestion being that where sulphate of ammonia is not included in the mixture, nitrogen in the form of nitrate of soda should not exceed about one-third of the total nitrogen applied.* It is unlikely in view of the present stock position in regard to nitrate of soda that large proportions of this manure will be included in suggested mixtures and the question may not therefore be of very much practical importance.

The question of the continued use of nitrate of soda for tea would appear, in fact, to depend entirely on the economic factor. Such information as is at present available indicates that any *future* supplies of nitrate of soda will only be available at a greatly increased cost and this manure will then be quite unable to compete in price per unit with groundnut cake. In such circumstances, since nitrate of soda possesses no special agricultural advantage which would justify a premium being paid for its use, it is suggested that when present stocks of nitrate of soda are exhausted this fertiliser should be replaced by groundnut cake provided stocks of the latter can

* In this connection see note at end of this article.—Ed.

be obtained at reasonable rates. It is realised that this will increase the bulk of mixtures and lead to increased freight charges, but, unless and until the cost of groundnut cake advances very materially, the use of the latter will prove very much cheaper than that of nitrate of soda at the rate at which new supplies of the latter are likely to be available.

It is obvious that if nitrogen formerly imported as sulphate of ammonia or nitrate of soda is in future to be obtained from groundnut cake, the quantity of the latter required will be very greatly increased. The question is whether such quantities will be available at reasonable rates. Groundnut cake is imported from India and since the war began has decreased materially in price due to the fact that India is at present cut off from her principal consumers of groundnuts and has been left with large stocks in hand. This position may well be changed in the future due to reduced sowings of groundnut. Enquiries are being made as to the probable future position and it can only be said at present that so far advices from India suggest that large stocks are still available at favourable prices.

The question will be closely watched but it must be stressed again that while groundnut cake is available at competitive rates there is, so far as the tea industry is concerned, no agricultural advantage to justify payment of a higher figure for nitrate of soda and no one will wish in these circumstances to utilise freight and foreign exchange to obtain this commodity.

Two other minor points may be referred to in regard to the use of greater quantities of groundnut cake. It is held in some quarters that weed seeds are introduced in this manure. Examination of a number of samples by the Institute lend no support to this belief and confirm similar findings made previously by the Department of Agriculture.

Another question that has been asked is whether the use of groundnut cake in place of the mineral nitrogen will temporarily slow down crop production. To this the Institute's manurial plots can supply the answer which is that in a comparison now extending over a period of several years little or no difference in availability has been found between groundnut cake and sulphate of ammonia.

So far as ammonium sulphate is concerned the ban on exports from the United Kingdom continues and stocks are now low. It is not improbable that pending exhaustion of this stock further voluntary rationing may be introduced in order that utilisation of the balance now available may be distributed over as long a period as possible.

Phosphatic Manures.—Through superphosphate is not available, adequate supplies of phosphoric acid have been obtainable though at a somewhat increased cost and no rationing has been required. It seems unlikely that the position will change materially in the near future.

Potassic Manures.—As mentioned earlier, imports of potash in 1940 were actually about 8.5 per cent higher than the average figure for the previous three years. It may therefore be asked why rationing of this material was introduced. The position is of course that the greater part of these imports were in the earlier part of the year and later supplies were restricted and the future position became more uncertain. It was therefore obviously desirable that stocks should be conserved and used with caution. There is no reason to think that the tea industry will suffer materially from the reduced quantities now allowed.

Summing up, it may be said that on the whole the position is much more favourable than might have been anticipated would be the case after eighteen months of war. So far as the tea industry is concerned it is not unlikely that there may be some reduction in the consumption of fertilisers in the near future. This, however, may be well offset under present conditions by a greater demand from the rubber industry. It seems unlikely therefore that the Island's total requirements in regard to fertilisers will be reduced. We may have some confidence, however, that these supplies will be available at a cost not too greatly in excess of that now prevailing.

Note.—Since the above was written proposals have been made to ration nitrogenous manures as follows:—

For Tea.—The allowance of inorganic nitrogen to be not more than one-third of the total nitrogen supply and not more than one-sixth of the total nitrogen to be in the form of sulphate of ammonia.

In the opinion of the writer it will be in the interests of the tea industry to accept this arrangement.—R. V. N.

THE LIFE-HISTORY OF THE SHOT-HOLE BORER OF TEA

C. H. GADD

E.M.N.

The Shot-hole Borer beetle (*Xyleborus fornicatus* Eichhoff, *fornicatior* Eggers) has long been known as a pest of tea, yet little is known of its life-history. The difficulty of determining the duration of the early stages of the beetle was pointed out by Green [2] in 1903, namely, that after the galleries have been opened or the infected branches removed, the young insects die for the want of their proper nourishment, which disappears with the desiccation of the surrounding parts.

The males have no wings beneath their wing cases and consequently cannot fly. They live and die within the galleries in which they were reared. The females are larger and have well developed wings capable of carrying the insect through the air for some short distance. Pairing takes place within the gallery in which the beetles are reared, and the impregnated females emerge through the hole which forms the entrance or exit to the gallery. They fly away and start fresh families in other branches.

Each female first bores a characteristic gallery in a branch and then lays her eggs within the tunnel. The eggs later hatch and the developing grubs feed upon the delicate mycelium of a fungus which grows upon the walls of the gallery. The galleries are completed by the parent insect; the grubs never extend them as do some allied species inhabiting dead wood. When full grown the larvae pupate, and later, adults emerge from the pupa cases. These transformations all take place within the galleries, out of sight. Consequently, it is impossible to obtain reliable information concerning the number of eggs laid, and the length of time the insect passes in the various stages, by direct observation.

Speyer [9] in 1917 published the following statement concerning the time expended in the various stages at an altitude of 4,000 feet above sea level:—

	Days
(a) Entrance of female to laying of first batch of eggs	25
(b) Egg stage	4
(c) Larval stage	25
(d) Pupal stage to emergence of adult ...	6
Total	60
Maximum number of young individuals found in one gallery	34
Average number of young individuals found in one gallery	15

The proportion of male to female is as 1 to 5.

No indication is given, however, as to the method by which these figures were arrived at.

In 1936 a further attempt was made to fill some of the existing gaps in our knowledge of the life-history of this Shot-hole Borer.

METHOD

The area selected for observation was in a field on Gonakelle Estate, Passara at an elevation of about 3,500 feet. In July, 1936, it was 21 months from pruning and was due to be pruned again the following October, *i.e.*, the pruning cycle was 2 years. All thin spindly branches were removed from 250 bushes leaving branches, each suitably labelled, of a thickness suitable for invasion by the Shot-hole Borer. These labelled branches were then carefully examined for existing galleries, the entrances of which were distinctively marked to allow any later formed gallery to be recognised. The branches were then examined daily by two observers and the entrance of every new gallery was encircled by a red line and a record made of the date it was observed. Such galleries were considered to be 1 day old at the date they were first observed.

Periodically, a number of attacked branches were cut out of the bush, placed in closed boxes and taken to the laboratory for examination. There the galleries were opened and a record made of their contents and other data. Observations were continued from July 8th to October 10th, a period of 95 days. During this time, galleries of all ages from 1 to 66 days were examined. The galleries

of any given age were not all examined on the same day. For instance 8 galleries were examined when 27 days old; the dates of examination were August 16th, 19th, 21st, and 22nd, September 15th (2) and October 8th (2).

POSITION OF GALLERIES

Galleries are most frequently formed in the branches at the nodes, the region of attachment of the leaves. Green [2] observed that the most usual point of attack was at leaf scars, and the writer [1] attributed much of the dieback after pruning of attacked bushes to that fact. In this investigation it was not always possible to determine with accuracy whether some galleries were situated at nodes or not, but of the 509 galleries examined, 318 (or 62 per cent) were at nodes, 13 at internodes and 178 were indeterminate. The internodal region is much longer than the nodal region; consequently, there should be more internodal galleries than nodal galleries, if the attack were entirely haphazard. The above figures show clearly that the beetles exhibit a marked preference for attacking the branches at the nodes.

The diameter of the branches at each gallery was measured in millimetres. The smallest branches had a diameter of 5.5 mm. whereas the mean size was 10.8 mm. (Standard deviation 2.2 mm.) or about half-inch in diameter.

CLASSIFICATION OF GALLERIES

Of the 509 galleries examined, 89 were found to be empty and 8 had been vacated by the female after laying a number of eggs. Other galleries were found to contain insects other than the Shothole Borer beetles; these were commonly Drosophilids (58 galleries), Lepidoptera (4 galleries) and Mites (8 galleries). Other galleries showed what has here been termed 'a moist exudation,' the nature of which is not understood, though possibly it is the product of a fermentation process. This 'moist exudation' was observed on 28 occasions, sometimes in galleries occupied by Drosophilids but not always. The significance of intruders and of the 'moist exudation' will be discussed later.

It seemed advisable to exclude the above mentioned galleries together with a few others, such as those in which the parent female beetle was dead, from a study of the borer under normal healthy conditions. In Table I are summarised the results of the daily observations. The galleries excluded temporarily from this investigation are enumerated in Table IA and the contents of the so-called healthy galleries are detailed in Table IB.

TABLE I

Shot-hole Borer Galleries

A.—Classification of Galleries

Age in days	No. of Observations	Empty		Containing Drosophilids			Vacated by female after laying	Excluded for other reasons	Healthy galleries
		No.	%	+S.H.B.	— S.H.B.	Total			
1-7	62	8	13	—	—	—	—	—	54
8-14	61	8	13	—	—	—	—	1	52
15-21	64	8	12	—	1	1	—	3	52
22-28	62	8	13	3	5	8	—	2	44
29-35	52	8	15	5	8	13	1	—	30
36-42	52	11	21	3	9	12	3	—	26
43-49	52	9	17	4	11	15	1	2	25
50-56	46	9	20	3	3	6	3	3	25
57-63	47	17	36	2	1	3	—	4	23
64-66	11	3	27	—	—	—	—	1	7
Total	509	89	—	20	38	58	8	16	338

B.—Contents of Healthy Galleries

Age in days	No. of healthy galleries	Females			Offspring					Mean			
		Non-layers		Layers	Eggs	Larvae	Pupae	Adults	Total	Offspring	Hatch	Pupation	Adults
		No.	%										
1-7	54	54	100	—	—	—	—	—	—	—	—	—	—
8-14	52	27	52	25	75	5	—	—	80	1.5	.1	—	—
15-21	52	15	29	37	243	66	—	—	309	5.9	1.3	—	—
22-28	44	5	11	39	233	191	4	—	428	9.7	4.4	.1	—
29-35	30	3	10	27	128	168	15	5	316	10.6	6.7	.7	.2
36-42	26	1	4	25	72	211	34	11	328	12.6	9.8	1.7	.4
43-49	25	1	4	24	54	166	45	50	315	12.6	10.4	3.8	2.0
50-56	25	2	8	23	48	115	24	61	248	9.9	8.0	3.4	2.4
57-63	23	3	13	20	36	83	17	37	173	7.5	6.0	2.3	1.6
64-66	7	—	—	7	5	24	2	13	44	6.3	5.6	2.1	1.9

The healthy galleries enumerated in Table IB have been divided into those which contain females that have laid no eggs, *i.e.*, non-layers, and those that have. The term 'non-layer' as used here, does not imply that such females never lay eggs, only that they had laid none at the time the galleries were examined. The galleries containing non-layers have been expressed as a percentage of the total healthy galleries; those figures show that during the first week the females were 100 per cent non-layers, and that that percentage decreased rapidly during the 2nd and 3rd weeks. The smallest percentage of non-layers (4 per cent) was observed during the 6th and 7th weeks; so it would appear that a few females never lay eggs although they make a gallery and live, apparently healthily, within it. These may be unfertilised females but there is no positive evidence to support such a conclusion.

In order to determine the number of eggs laid by any female, larvae, pupae and young adults must be counted as eggs. Such totals are given in Table IB in the column headed 'total offspring.' The mean number of eggs laid, 'mean offspring', is obtained by dividing each total by the number of healthy galleries opened during that week. The mean is therefore an average of the whole population including non-layers. Similarly the mean number of eggs hatched is obtained by dividing the sum of larvae, pupae and adults by the number of healthy galleries examined that week.

GRAPHS

The mean values given in Table IB are represented graphically in Fig. 1, where it will be seen that egg-laying began during the second week. Actually, eggs were first recorded on the 10th day when two galleries were found to contain eggs; one contained four and the other one egg. In the following weeks the mean number of eggs increased, more rapidly at first, until the 6th week when a mean of 12.6 per gallery was found. After the 7th week the mean number of eggs decreased regularly week by week.

Such a decrease can only be explained by the removal of offspring, either as eggs, larvae, pupae or adults, from the galleries. Larvae and pupae do not leave the galleries of their own free will, but adult females do. Adult offspring began to occur in the galleries in the 5th week but it was not until the 7th week that they were found in appreciable numbers, and at that stage they were ready to emerge from the galleries. It is probable, therefore, that many adults left the galleries in the 8th week and such departures resulted in a short count of offspring in the 8th and following weeks. Such departures would also be reflected in the curves representing larvae and pupae.

The eggs laid during the first week hatched after a given interval. If we assume for the time being that that interval was one week — it will be determined more accurately later — the eggs laid during the first week would be expected to occur as larvae in the second week. Similarly, the same number of eggs found in the second and 3rd weeks should occur as larvae in the 3rd and 4th weeks. If, then, there were no sampling errors, the curve representing larvae would run parallel with that representing eggs. By similar argument it may be shown that the curves for pupae and adults should also be roughly parallel with the egg curve, at least during the early parts of the graphs. It will be seen from Fig 1 that although there is a rough similarity between the curves, they are by no means parallel at their beginnings. The possible causes of their divergence from the parallel will be discussed later.

In the 6th week a mean of 12.6 eggs per gallery had been laid, but at no time was a mean of 12.6 hatched eggs per gallery found. The maximum number (10.4) of hatched eggs (larva curve) was found in the 7th week. At that time adults were emerging from their pupa cases and possibly escaping from the galleries, so it is unlikely that the maximum mean number of larvae found would ever equal the maximum mean number of eggs laid. The difference observed (2.2) however seems too large to be explained merely by the departure of adults from the galleries. A more detailed study of the early part of the graphs may throw further light on this and other problems.

In Fig. 2 are shown the mean daily observations of egg-laying and hatching over a short period. Pupa and adults are given as means of 3 days, because the number of available galleries each day during that period was too small to be of real value. It will be seen that the dotted lines joining these observed values are by no means straight, as might be expected from theoretical considerations alone. The number of galleries opened daily was relatively small, and consequently, the sampling errors are fairly large. The fluctuations in the graph are largely due to sampling errors.

It is possible, however, to calculate formulae to represent the straight lines which best fit each set of observations. The calculated lines have been drawn in Fig. 2 as unbroken lines through a period of 12 days, the data from which were used in making the calculation. Any prolongations of the theoretic lines are made by broken lines.

The formula of each theoretic line is as follows:—

Eggs	...	$y = -5.21 + .623x$
Larvae	...	$y = -7.10 + .463x$
Pupae	...	$y = -7.66 + .251x$
Adults	...	$y = -9.75 + .260x$

PERIODS AND RATES

When the theoretic lines in Fig. 2 are prolonged downwards they cut the X or time axis at definite points. The egg line cuts it at 8.4 days. This indicates that before 8.4 days no eggs are to be expected within the galleries, but after that date eggs may be found. In other words, egg-laying begins, on the average, at 8.4 days, *i.e.*, during the 9th day counting from the time the beetle began to form her gallery. Similarly it may be determined that hatching began at 15.3 days, pupation at 30.5 days and adults began to emerge 37.5 days after the commencement of gallery formation.

From these times are obtained the following average periods.

Pre-egg laying	...	8.4 days
Incubation period	...	6.9 ,,
Larval period	...	15.2 ,,
Pupal period	...	7 ,,

If 2 or 3 days are allowed from the emergence of a female from her pupa case till she starts to form a new gallery, the life cycle of the beetle from egg to egg amounts to about 40 days, not 24 days as stated by King [6]. The figures given here are averages based on galleries examined over a 12-day period, whereas King's figures are the shortest observed.

A comparison with the periods given by Speyer, and quoted earlier, shows considerable differences. In particular, he gives Pre-egg-laying and larval periods of much longer duration than occurred here. Possibly, these differences may be due to the different elevations at which the experiments were made. His data refer to the life history at 4,000 ft. which is nearing the upper limit at which this borer is found.

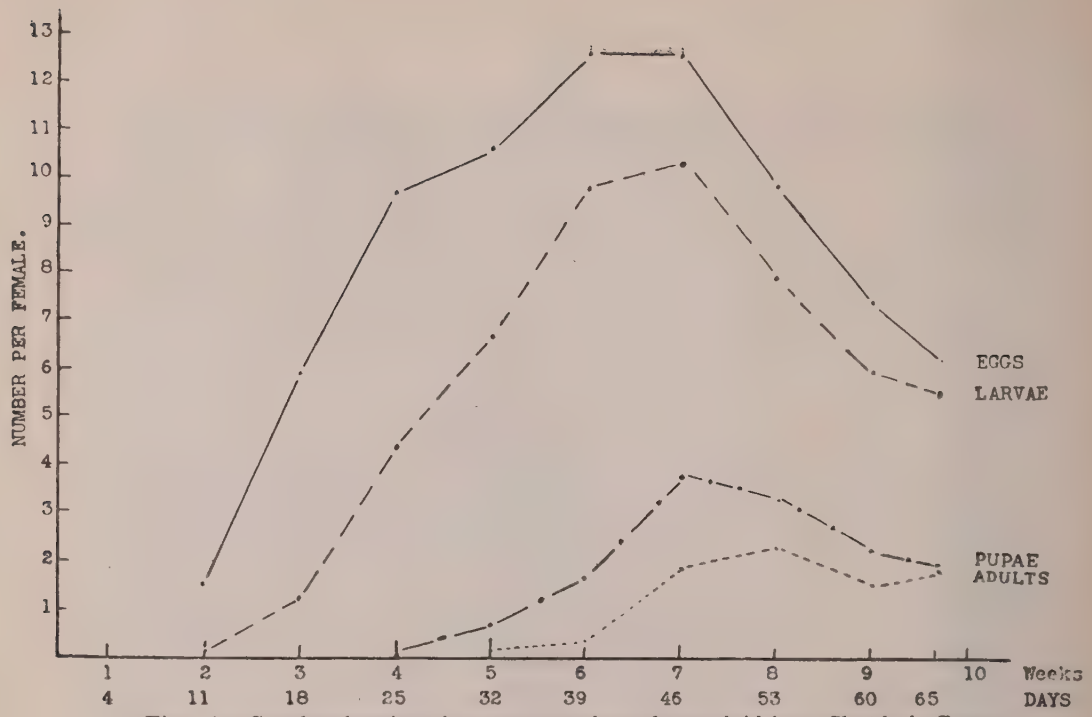

Fig. 1.—Graphs showing the mean number of eggs laid by a Shot-hole Borer population, together with the mean numbers of larvae, pupae and adults which result.

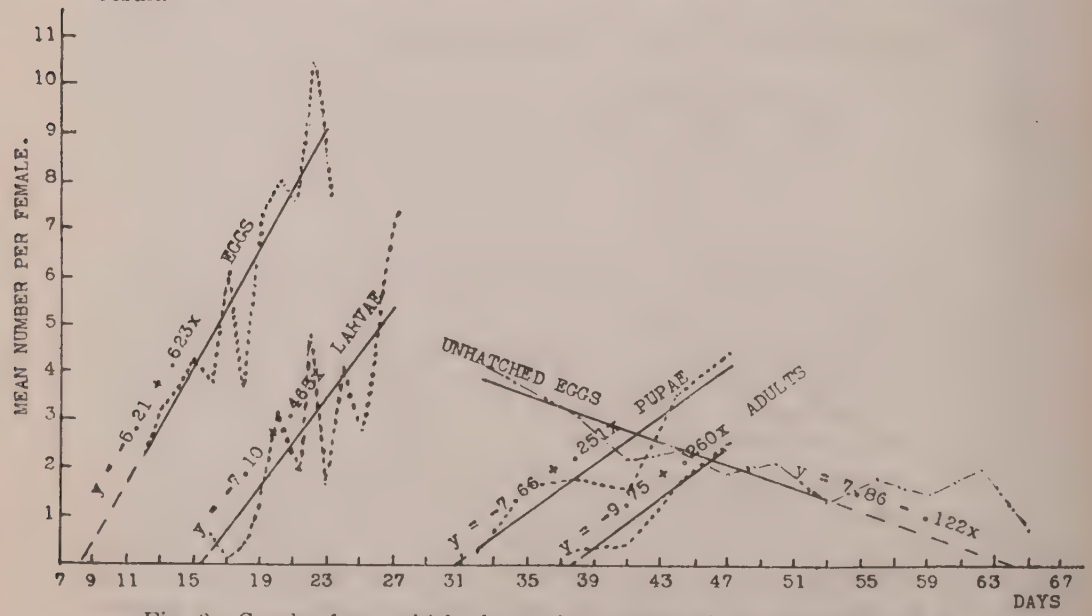

Fig. 2.—Graphs from which the various stages of the life-history of Shot-hole Borer and the mean rates of egg-laying, hatching, pupation and emergence of adults have been calculated.

The equations given above also indicate the rate at which egg-laying, hatching, etc., occur during the periods studied. The term .623x of the equation $y = -5.21 + .623x$ gives the average rate at which the mean number of eggs have increased from day to day, viz. .623 per female. This means that a population of female Shot-hole Borers between the 12th and 23rd days inclusive, after beginning to form galleries, lay eggs at the average rate of .623 eggs per female per day. The rates for egg hatching, pupation and emergence of larvae are given similarly by their respective equations.

The average rates of egg-laying, etc. shown by this population of borers are :—

Egg laying	...	.623 per day
Hatching	...	.463 ,, ,,
Pupation	...	.251 ,, ,,
Adult emergence	...	.260 ,, ,,

These values also indicate to what extent the graphs from which they were obtained are parallel. If the graphs were parallel as theoretically we should expect, these values would be equal. The graphs for pupation and adult emergence are nearly parallel, but the others are not. These figures indicate that although .6 eggs per day are laid, only .3 adults emerge per day, or in other words only 50 per cent of the eggs laid develop into adults.

It has already been mentioned that the value for the egg-laying rate given above gives little indication of individual performances. All females do not begin to lay at the same time. During the first week all females were non-layers; in the 2nd, 3rd and 4th weeks that percentage fell gradually to 52, 29 and 11 per cent respectively. There was therefore an appreciable number of non-layers between the 12th and 23rd days which is the period of egg-laying here studied in detail. The eggs found on those days have been shared, when averaging, amongst all the females, including non-layers. If instead of averaging the eggs amongst all females, they are averaged only amongst those females which have contributed to the total, *i.e.*, layers only, and proceeding as before, an equation, $y = -8.48 + .927x$, is obtained. This gives a mean egg laying rate of .927 eggs per day per laying female. This is a much better estimate of performance by the individual. It means that after a female has started to lay eggs she continues at the rate of .927 or about 1 per day.

How long does a female continue to lay eggs? An estimate of this period may be arrived at from a consideration of the unhatched eggs. In Fig. 2 are shown the mean number of unhatched eggs at 3-day intervals found in the galleries from the 31st to the 66th day, and the straight line which best fits the observations from the 31st to 54th day has been calculated. This has the formula $y = 7.86 - .122x$, showing that unhatched eggs were disappearing from the galleries at an average rate of .122 per day. During that period more eggs were being hatched than were laid. At that rate, eggs would completely disappear from the galleries after 64.4 days. In that event, egg-laying would have ceased 7 days earlier, *i.e.*, on the 58th day because it takes, on the average, 7 days for an egg to hatch.

TABLE II

Contents of galleries containing more than 25 offspring

Days	No. of possible laying days	Eggs	Larvae	Pupae	Adults	Total
35	26	6	18	4	—	28
36	27	6	16	5	—	27
37	28	7	17	3	—	27
39	30	6	18	2	3	29
40	31	3	24	5	1	33
45	36	1	15	7	7	31
51	42	—	13	4	10	27
52	43	9	19	1	5	34
59	50	10	12	4	5	31

As egg-laying started during the 9th day, an estimate of the average egg-laying period of the population becomes 49 days. This is probably an overestimate of the average number of days any *individual* female lays eggs, because as already shown, some females did not begin to lay eggs till the 3rd or 4th week; so the eggs considered in this calculation are probably those of females which were late in starting laying. Allowing therefore that a female borer lays one egg per day it is unlikely that she will lay as many as 50 eggs.

The highest number of offspring found in any gallery was 34 on the 52nd day (*cf.* Speyer who gives the same maximum number). In only 9 galleries were more than 25 found. Details of these are given in Table II, arranged in order by the age of the gallery. By deducting 9 days from the gallery age, *i.e.*, the average period taken in making the gallery before egg-laying, an estimate of the possible number of laying days is arrived at. For the first 5 galleries in the list there is fairly close agreement between the number of offspring and the number of possible laying days, which indicates, if the female has laid at a uniform rate during the whole period, an egg-laying rate at 1 per day. This is very near the average rate given earlier. Assuming then, a uniform rate of 1 egg per day we should expect the numbers of eggs, larvae and pupae in individual galleries to equal roughly the number of days in the incubation, larval and pupation periods respectively, viz. 7, 16 and 7 respectively. Note that this expectation depends upon a fairly uniform laying rate, and not on eggs being laid in batches, as indicated by Speyer by his reference to the 'first batch of eggs.' The females in the first 4 galleries had evidently each laid an egg for the last 5 or 6 days, so presumably had not reached the end of their egg-laying periods. The female in the gallery 40 days old appears to have ceased laying 1 or 2 days earlier, and the female in the gallery 45 days old 4 or 5 days earlier. In that case the egg-laying periods of these beetles were 30 and 33 days respectively. The beetle in the gallery 51 days old must have stopped laying more than seven days earlier, possibly 9 or 10 days earlier, judging from the shortage of larvae. That again gives an estimate of the egg-laying period of individual females as about 32 days.

The number of eggs in the galleries 52 and 59 days old seem unduly large, and suggests that more than one female is contributing to the number. The age of the galleries makes it possible that at least some of the eggs are being laid by female offspring. It would, however, be unwise to draw any definite conclusion about offspring laying eggs in the parent gallery from these two observations alone. It will be sufficient to accept them as indications of the possibility. Green has noted that occasionally an impregnated female may extend its original home though that procedure appeared exceptional.

The numbers of pupae found in all the galleries given in Table II except for the gallery 45 days old are somewhat smaller than expected. Our estimate for the pupation period may therefore be a little too large.

The maximum number of offspring found in any one gallery was 34, and from the foregoing it seems unlikely that number would rarely be exceeded.

MALE-FEMALE RATIO

In all, 141 pupae were found in the galleries and of these 33 or 23.4 per cent were males. Also, 177 adult offspring were examined; of these 48 or 27.1 per cent were males. The difference between these two estimates is not of statistical significance ($\chi^2 = .57$) and the observations may therefore be amalgamated. In this population, then, 81 males occurred for every 237 females or 1 male to 3 females.

Rutherford [7] has given two estimates of the male-female ratio of Shot-hole Borer. The first, derived from a few galleries was 1 to 5 which agrees with Speyer's estimate, and the second from another and larger count, 1 to 12.25. In arriving at these estimates he appears to have included parent females in the count, and that naturally increases the number of females. The estimate given above is calculated entirely on brood and so gives a more reliable estimate of the ratio in which males and females are born.

It has already been shown that although eggs were laid at the rate of .623 per day, adults emerged only at the rate of .26 per day. The rates of pupation and emergence of adults were approximately equal. Eggs amounting to .363 per day remain unaccounted for. The hypothesis that some adults left the galleries before being counted does not afford an entirely satisfactory explanation, because even by the 27th day, before adults began to emerge from the pupa cases, a loss of .16 eggs per day (egg rate minus larval rate) remains to be accounted for.

The most likely time at which losses might occur is while the young are in the grub or larval stage. Also it seems probable that because of the enclosed space in which the borer lives and raises a family, she must pay considerable attention to general hygiene. It would not be surprising therefore, if and when deaths occur, the female should remove the bodies from the gallery. To leave the dead bodies of larvae within the gallery to decay would be a serious menace to the health of the rest of the brood. Bodies removed by the female parent cannot be counted and consequently an estimate of the number of eggs hatched would be lower by that number, which in turn would reduce the estimate of the rate of hatching.

TABLE III

Effect of Female Parent on the Number of dead larvae within galleries

		No. of galleries	Ratio to living larvae
Galleries *with* living female	With dead larvae	5	9:21
	All larvae alive	144	—
Galleries *without* living female	With dead larvae	7	18:2
	All larvae alive	3	

If, as suggested, the female parent removes dead bodies from the galleries, more dead bodies should be found in those galleries which for some reason or other contain no female parent than in those in which the female is active. In Table III all galleries containing larvae, alive or dead, have been classified according as they contained a female parent or not. From the data given there it is evident that in the absence of the female parent a much higher percentage of galleries contain dead larvae, namely 70 as compared with 3.4 per cent when live females are present; and the ratio of dead to living larvae is higher.

The writer has been unable to find any reference in literature to direct evidence of the removal of dead larval bodies from the galleries by this borer beetle, but in view of the evidence given here it appears probable that something of the sort does happen.

It must be pointed out, however, that the evidence concerning the difference in egg-laying, hatching and adult emergence rates was collected from 'healthy' galleries alone, and in them one dead larva only was observed, whereas the data given in Table III was collected from all galleries, some of which contained Drosophilids. The question therefore naturally arises concerning these Drosophilids, and to what extent they themselves cause death amongst larvae.

DROSOPHILIDS

Drosophilidae are a family of small flies. Many of them are attracted to decomposing fruit, cider presses, wine vats, etc., to which they are attracted by certain products of fermentation. Eggs are

laid in rotten fruit and in decomposing matter of all kinds. That many species of flies "are attracted by various individual by-products produced as a result of fermentation of different kinds" [3] and that the larvae of one species of *Drosophila* is known to "require a growth promoting substance present in yeast in order to complete their development" [3] suggest that Drosophilids are attracted to Shot-hole Borer galleries, either because of the presence of decaying animal or vegetable matter or because of some fermentation process which occurs within certain galleries.

Rutherford [7] recorded Drosophilid larvae and pupae within shot-hole galleries but was unable to say to what extent they preyed on the beetle colonies. He demonstrated that the Drosophilid larva was an unwelcome tenant of the gallery, as when he tried to introduce a Drosophilid grub into an occupied shot-hole gallery, the female repeatedly ejected the grub by backing out of the gallery pushing the intruder behind her. It does not follow that because Drosophilids are unwelcome they are predaceous on the beetle's progeny; they may be attracted by the ambrosia fungus within the gallery and go there to feed on it. In that case the fly is probably to be regarded as an enemy to the colony because by feeding within the gallery it may serve to diminish the number of beetles reaching maturity.

Senior-White [8] has described a Drosophilid from shot-hole galleries of tea as *Phortica xyleboriphaga* which he says is almost certainly the one referred to by Rutherford. He also states "Recently Mr. F. P. Jepson (Entomologist in charge of Shot-hole Borer investigations) informs me (*in litt*) that he has seen the larva eat a pupa of the beetle, tunnelling completely inside, and sucking it dry in about 20 minutes." Jepson [4] has pointed out the difficulty of studying the habits of the Drosophilid fly in that the larvae perish a few hours after removal from their natural surroundings, but he states that isolated instances have occurred where the larvae have fed upon the larvae and pupae of *X. fornicatus* immediately after removal from the galleries. Such evidence clearly indicates the predaceous habits of this fly.

During this investigation Drosophilids were found in 58 or 11.4 per cent of the galleries examined. Jepson [4] found it in 183 or 5.2 per cent of 3,504 galleries and later [5] in 6.8 per cent of 1,300 galleries examined on another estate. It may be seen from Table IA that the Drosophilid-invaded galleries were found mostly in the 5th, 6th and 7th weeks, when borer larvae were also most numerous,

Some Drosophilids were found in galleries otherwise empty as well as in occupied galleries. It may be seen from Table IA that empty galleries were found even in the first week. These of course were galleries which had been made, partially or wholly, by beetles which left them before beginning to lay eggs. Such galleries amounted to approximately 13 per cent of those examined until the 6th week, when the percentage increased somewhat. Towards the end of the experiment the percentage of empty galleries was at its highest because at that stage some of them were galleries from which the whole colony had emerged.

TABLE IV

Shot-hole Borer Galleries and Drosophilids

	Empty	With Shot-hole Borer	Total
Galleries containing Drosophilids	20	38	58
Galleries without Drosophilids	89	362	451
Total	109	400	509

In Table IV all galleries examined have been classified according as they contained Drosophilids or not, and whether they were otherwise empty or not. Twenty (or 35 per cent) of the Drosophilid-containing galleries were empty whereas only 20 per cent of galleries without Drosophilids were empty. This difference is probably of statistical significance ($\chi^2 = 6.3$) because it is likely to occur only about once in 70 times as a result of sampling alone. Drosophilids were found more frequently in empty galleries than would be expected if they entered galleries at random. Do they, then, for some reason prefer empty galleries or do they cause the galleries to become empty, or are the galleries selected for some reason other than their emptiness ?

MOIST EXUDATION

Many Drosophilids are attracted by certain products of fermentation, and mention has already been made of the presence in 28 galleries of a moist exudation which is suspected to be the results of a fermentation process.

Rutherford [7] noted that from certain galleries a sour smelling substance exuded and it was in such galleries that Drosophilids were most frequently found. Jepson [5] also reported that the galleries which contain the larvae of this fly almost invariably emit a putrid odour.

Speyer [10] also refers to a foul-smelling exudation from certain galleries. He writes: "When an incomplete gallery containing insects is about to heal, evidence is shown that the drainage of the tunnel is impaired. A considerable pressure of liquid in which the inmates are drowned forces decaying larvae and 'pellets' of fungus, teaming with bacteria through the entrance . . . . . When the foul-smelling exudation has ceased, the formation of a 'callus' proceeds."

These investigations lend no support to Speyer's view that the exudation results from impaired drainage nor that the exudation precedes healing. That the exudation may cause death amongst the colonies by drowning is evident, but no case has been seen in which the occupants are washed out as he describes. It seems more probable that the exudation is the result of a fermentation process and that the Drosophilids are attracted to galleries owing to that process. Alternatively the Drosophilids may start the fermentation by bringing into the gallery a ferment. Either hypothesis would explain Rutherford's observation that Drosophilids most frequently occur in those galleries which also exhibit the exudation.

TABLE V

Association between Drosophilids and Moist Galleries

	Drosophilids		Total
	Absent	Present	
Galleries *with* exudation	11	17	28
Galleries *without* exudation	440	41	481
Total	451	58	509

The association between Drosophilids and galleries exhibiting a moist exudation is shown in Table V, from which it may be calculated that of the galleries with the exudation 61 per cent also contained Drosophilids, whereas in the absence of exudation only 8.5 per cent contained Drosophilids. The difference is too great to be due solely to chance and we must conclude that there is a close association between the moist exudation and invasion by

Drosophilids. These figures, however, afford no evidence as to which comes first, the fly or the exudation. Taking into consideration the knowledge concerning the feeding habits of other Drosophilids it seems probable that the Drosophilids are attracted to those galleries in which some form of fermentation is taking place as shown by the presence of an exudation.

Of the 28 galleries with exudation, 6 or 28 per cent were empty. Of the remainder, 8 or 36 per cent contained no female, 7 or 32 per cent contained dead females, and an equal number contained living females. Of the 7 galleries with living females 2 had no other contents, 4 contained dead larvae and only one contained no dead bodies. It is evident therefore that the presence of an exudation is associated with high mortality amongst the beetles. This may be entirely due to the exudation drowning the insects, or partly to the Drosophilids which are attracted to such galleries.

OTHER INTRUDERS

Mites were found in 8 galleries and Lepidopterous larvae in 4 galleries. The number of occasions on which these intruders were found in the galleries were too few to be of value in an investigation such as this, so no attempt is made to determine their importance here.

SUMMARY

This paper describes experiments carried out in 1936 on an estate in Passara at an elevation of 3,500 ft. to determine fuller details of the life-history of the Shot-hole Borer beetle of tea.

509 galleries of known ages were opened and their contents examined.

The average times spent by the beetle in its various stages of development were: From commencing boring the gallery to egg-laying 8 days, egg period 7 days, larval stage 15 days, pupal stage 7 days. The life-cycle, egg to egg, is about 40 days.

After beginning to lay eggs a female lays on the average 9 eggs in 10 days and lays a maximum of about 34 eggs. Egg-laying is very unlikely to exceed a period of 49 days.

Some females laid no eggs during the period of observation although they remained within the galleries they had made. Others made galleries and left them before laying any eggs.

More eggs were laid than the number of adults which emerged from the galleries. It is suggested that dead bodies are removed by the parent female.

The borers prefer stems about half-inch in diameter in which to make their galleries and most frequently select the nodes as places for entry.

Fermentation occurs in some galleries and causes an exudation of a sour-smelling fluid. These galleries also attract Drosophilid flies and contain most dead beetles. Deaths may result from the fluid itself and/or from the Drosophilids which have been reported to be predaceous.

ACKNOWLEDGMENTS

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REFERENCES

1. Gadd, C. H.—Annual Report for 1928, Tea Research Institute Bulletin No. 3, p. 13, (1929).
2. Green, E. E.—Shot-hole Borer, Circular and Agriculture Journal R.B.G., Ceylon, Vol. II, No. 9, (1903).
3. Imms, A. D.—Recent Advances in Entomology. London. 1931.
4. Jepson, F. P.—Shot-hole Borer of tea, *Tropical Agriculturist*, Vol. 55, pp. 280-289, (1920).
5. — Shot-hole Borer Investigations, *Tropical Agriculturist*, Vol. 56, pp. 23-30, (1921).
6. King, C. B. R.—Annual Report for 1936, Tea Research Institute Bulletin No. 17, p. 34, (1937).
7. Rutherford, A.—Some notes on *Xyleborus fornicatus* Eichh. (Shot-hole Borer), *Tropical Agriculturist*, Vol. 42, pp. 132-139 and 220-222, (1914).
8. Senior-White, R. A.—New Ceylon Diptera, *Spolia Zeylanica*, Vol. XI, p. 381-395 (1921).
9. Speyer, E. R.—Shot-hole Borer investigations, *Tropical Agriculturist*, Vol. 48, pp. 152-155, (1917).
10. — Shot-hole Borer of tea, Department of Agriculture, Ceylon, Bulletin No. 60, (1922).

THE PRESENT POSITION OF TEA SELECTION IN JAVA

(REVIEW)*

T. E. T. BOND

To a certain extent it is true to say that selection has been practised in an empirical fashion for as long as tea has been cultivated, whether in Java or elsewhere, but it was not until the beginning of the present century that a definite programme involving rational methods of selection was laid down. The first step was the establishment of a selected seed garden in Tjinjiroean in 1905. This work was extended in 1910 in co-operation with the Proefstation voor Thee and with the appointment of Cohen Stuart as the first tea selectionist. In these early days, the main object was selection for type or jât of the seed bearers, and it was not until 1920 that Cohen Stuart began selection with the definite aim of improving yield. Selection work with a perennial crop involves, sooner or later, the need for a method of vegetative propagation by which the selected material can be multiplied and its characteristic properties maintained. In Ceylon, the emphasis from the start has been on propagation by cuttings, while the Dutch workers have concentrated on grafting and budding methods, similar to those which are widely employed in fruit growing. At first, the "crown grafting" method was in vogue, and the early expansion of the selection work was impeded by the precarious and inadequate success obtained by this process.

A great step forward was made with the re-introduction of budding in 1932. Budding had already been employed on a small scale as early as 1917, but for some reason its real value had escaped attention. When once a reliable method of vegetative propagation was available there was every inducement to proceed with mother tree selection on a large scale, and in the relatively short period since 1932, the Java workers have selected some 2,000 bushes from which already more than 1,750 clones have been tested, both in plucking and as seed bearers.

* This article is based on and in part freely translated from recent papers by S. J. Wellensiek and I. J. H. van Emden respectively, in *De Bergcultures*, Vol. 14, pp. 223-6 (1940), and Vol. 15, pp. 118-24 (1941),

CLONE TESTING

The clone testing experiments, which are now more or less complete, form the peak of the selection programme and deserve to be described in some detail.

Why Clone Testing is Necessary.—A clone is the progeny raised by vegetative means from a selected bush, the so-called mother tree, which, in so far as its hereditary constitution is concerned, is reproduced exactly in each member of the clone (assuming the absence of vegetative mutations or "sports"). Scientifically speaking, a clone, however large or however widespread, is a single individual. It is the realisation of this fact that is apt to create difficulties in the way of appreciating the need for clone testing. The fact that successful results may sometimes be obtained without clone testing does not affect the general position. The aim of selection in these experiments is the improvement of yield, and there are abundant data to prove that the yield of a clone need not, and in fact often does not run parallel with the yield of the mother tree.

A tea plant develops — like any other organism — under the influence of two sets of factors, hereditary and environmental. That the latter may exert a predominant influence may be seen from the marked response of an estate to different levels of cultivation. *In considering a certain bush which it is desired to select as a mother tree, we cannot foresee how far the properties which have attracted our attention are inherent in the genotype, and how far they are the result of local environmental influence. To form an opinion it is necessary to propagate the given plant vegetatively, and to grow on the progeny in such a way that the influence of external factors can be eliminated or recognised.* This is the essence of clone testing.

The figures in Table I, which are selected from a Tjinjiroean experiment, indicate the importance of external conditions in determining the yield of a bush on the estate. In the Table, the productivity of the mother trees is expressed as a productive index, which is the ratio of the yield of the mother trees to the general average yield of the estate from which it was selected. The yield of the clones is expressed in grams per plant per plucking. It is obvious at a glance that the clones with the highest productive index do not always give the highest yield and *vice-versa*. In fact the correlation coefficient between the two sets of figures is only **0.1804 + 0.1232,** whereas a much higher value, approaching unity, would have been obtained if genetic constitution and not external conditions, had been the chief determining factor for yield. The need for clone testing is amply demonstrated by these figures.

TABLE I

Productivity of Mother Trees and of Clones derived from them.

Clone	Productive index (of mother tree)	Yield in grams fresh weight per plant per pluck (of progeny)	Clone	Productive index (of mother tree)	Yield in grams fresh weight per plant per pluck (of progeny)
a	1.9	69.5	p	2.8	56.7
b	6.5	68.3	q	1.9	56.2
c	5.7	66.5	r	2.3	56.1
d	6.1	62.3	s	1.8	55.7
e	4.8	62.3	t	2.2	55.4
f	2.3	61.6	u	2.2	54.9
g	2.0	60.4	v	8 9	53.9
h	3.7	60.0	w	4.1	52.7
i	2.0	59.1	x	2.3	52.0
j	2.2	58 8	y	4.4	52.0
k	4.0	58.8	z	1.9	51.2
l	3.8	57.4	a′	4.5	51.1
m	3.9	57.3	b′	4.0	50.5
n	7.3	57.1	c′	1.8	50.2
o	1.9	56.9	d′	3.1	49.9

How the Testing is done.—It has already been stated that the aim of clone-testing is to grow the clones on in such a way that the influence of external conditions can be eliminated or at any rate recognised (and allowed for). In order to obtain this object, a degree of replication of the experiment is necessary.

The simplest method of replication is to put out the budded plants at random and to determine the yield of each individual bush. By calculating the average yield for each clone and the standard error for the experiment one can obtain a significant estimate of the productivity of the clones and of the differences between them. This method has several disadvantages of which the most serious are the relatively small number of bushes to which it can be applied, the great practical difficulties in plucking, and the high errors in weighing compared with the actual weight of leaf obtained.

The next step was the introduction of the row-test method which is now used in all the Tjinjiroean experiments. This is a randomised block layout in which eight objects are compared, *e.g.*, eight clones, or seven and one control. Each clone is represented in each of four blocks by a row of eight plants, the row being treated as a unit for plucking and in weighing the produce. The plants are set at intervals of 125 cms. (about 4 feet) with the same distance between the rows. Thus each block of eight rows needs an area of 10×10 metres (32 ft. square) and the whole experiment of four blocks, 20×20 metres (64 ft. square).

The advantages of the row-test method are as follows : the number of bushes needed for each clone is relatively small compared with the accuracy of the results obtained, the layout is compact and utilises the ground to the best advantage, and the yield determinations are simple. Under favourable conditions, *i.e.*, with relatively uniform batches of planting material, and an area of ground free from excessive variations in fertility, the method will detect significant differences in yield of the order of 15-20 per cent. However, there are certain inherent difficulties which cannot be overcome by attention to homogeneity of the material or layout and the chief of these is that of the mutual influence of the clones. Thus a relatively slow-growing clone will be subjected to unfair competition from a relatively fast-growing clone in an adjacent row.

As an additional control to the row-test experiments, the tests may be repeated with double the number of blocks, (*i.e.*, 8 replications of 8 plants per clone), or, if adequate material is available for the large number of plants required, plot experiments may be set up in which the replications consist of whole plots or blocks of each clone.

It is important to realise that, necessary as clone testing is, there is no single experiment which will give an absolute measure of the productivity of different clones under all circumstances. The yield of a clone in a testing experiment is reckoned as the mean yield of the replications, while the standard error gives a measure of the variability of those means. However, this "error" applies only to the particular time and place of the experiment, and to none other. For instance, if in the test clone "A" gives 25+5 grams more yield per plant than clone "B", it can be forecasted that under the conditions of the test there is a 95 per cent chance that the difference will lie between 15 and 35 grams. But no forecast can be made as to the relative behaviour of the two clones in a later occasion, perhaps on another estate, or in a different climate. There is even no guarantee that the yield of clone "A" will exceed that of clone "B" at all. It may be asked what is the value of testing, if the result is only valid for one place, in one season, for one age of the plant, or for one system of cultivation ? The answer is that although these difficulties indeed exist and do provide an explanation for the peculiar discrepancies that are sometimes encountered, yet, on the whole, and provided that the extreme cases are omitted, it can be said that *most clones react in the same way to changes in their conditions of growth, and that the differences between them will therefore tend to persist.* They will, however, exhibit a much wider variation than could be forecasted from the standard error of a single experiment. In time of course the results of clone tests will be supplemented by the experience of all those planters to whom selected clones are distributed from growth on a field scale.

The results obtained.—The first impression of the clone tests results is disappointing, since the great majority of the clones have little more than average yield. *Usually only about 10 per cent of the clones is kept for further testing.* However, among these, certain clones are undoubtedly outstanding and in them the limit of improvement by selection would appear to have been reached. That this improvement is considerable is shown by the number of clones in the final selection yielding from 100 per cent to 150 per cent more than unselected material. By the use of these clones, therefore, *yields of at least double the present figures can be expected.*

The predominant influence of external factors on the performance of the mother trees is again emphasised by these results. Beyond the fact that clones from average, (*i.e.*, unselected) and from good mother trees are usually distinguishable in testing, there is no necessary relationship between the yield of a clone and the performance of the mother tree. It is therefore waste of time to spend

too long on the selection of mother trees; clone testing is of paramount importance and as much time as possible should be left for this stage of the work. As the clones are inevitably tested at an early stage in their life, the mother trees should be selected from as young fields as possible, *i.e.*, under conditions more nearly approaching those of the clone test.

NURSERY SELECTION

Nursery selection is considered from two different aspects; that of the supply of young plants to put out (as in Ceylon) in the field, and that of the provision of stumps to serve as understocks for budded plants of selected clones.

Selection in the nursery of plants to be grown on as supplies depends on the hypothesis put forward by Cohen Stuart in 1929, that the strongest seedlings, judged by weight of prunings or by the diameter or height of stem, would also be the best leaf producers. The question raised is analogous to that considered in relation to clone testing, namely, as to how far the differences between nursery plants are due to external circumstances of a fortuitous character, rather than to genetic factors controlling productivity. At least some appear to be hereditary as may be seen by comparing the subsequent growth respectively of plants taken from the edge and from the middle of the nursery beds. The average difference between the two groups disappears within two years of transplanting while the differences between plants within each group are partly maintained. The improvement of yield may be the declared aim of nursery selection of supplies, but it is questionable whether the improvement, when effected, is really of a lasting nature. In any case, the increases obtained, about 15-20 per cent of the average for unselected plants, are relatively slight compared with those obtained by clonal selection.

Nursery selection is of greater importance for the present day selection programme as a means of obtaining improved stocks for budded clones. In the interests of economy, the selection should be carried out as early as possible in the life of the plant. The seed should be selected simultaneously for size and specific gravity (by flotation in sugar solution) before planting. Selection for one of these characters alone may be prejudicial to the other. Very striking results have been obtained by selective thinning of closely planted seed beds. The thinning is done at a single operation, and up to 90 per cent of the plants can be removed. Obviously, these methods depend on each estate having access to a plentiful and cheap supply of seed.

The exact influence of the stock on the subsequent growth of the budded clone is still an open question. It has been shown by experiment that stocks showing great vigour of growth exert a favourable influence on the success of budding and on the growth subsequently produced. This, in fact, is the benefit derived from nursery selection of stocks. It is further established that the productive capacity of budded plants of a given clone can run to a certain extent parallel with the potential productive capacity of the stock. Nursery selection is again the only means available of making use of this fact. Further investigations are needed to determine whether the stock can influence the type (jât) of the budded clone, or the quality of the manufactured product. Nothing is known of possible stock influence on the behaviour of budded seed-bearers.

ESTABLISHMENT OF BUDDED PLANTS

Budding is a routine operation in which high percentages of success are obtained. Growth of the buds is slow however at high elevations and attempts have been made to evolve a method of propagation in which green shoots could be employed as scions and a more rapid development encouraged. Such a method, which appears to combine the properties of grafting and budding, and from which great advantages are expected has recently been published* — it may be described in English as "couple-grafting."

For the establishment of budded plants in the field there are four methods available: (a) Budding of nursery plants, which are planted out when the buds have swollen; this furnishes a less regular supply of plants which come into bearing no earlier than: (b) Budded stumps, which are budded in the nursery and planted out as stumps 1-1½ years after budding; this method is preferred in all circumstances: (c) Young plants can be budded *in situ* in the field, or: (d) Old plants can be budded on to the new shoots produced after collar pruning.

In the long run, the replacement of existing fields by a monoclone complex — an area of budded plants from a single clone — is aimed at. Normally seed-bearer plots will be maintained only as a source of plants to serve as stocks, and nursery selection will be sufficient to maintain the quality of these. Highly selected seed-bearers will however be established for the purpose of procuring seedling families which will be good enough to replace the best existing clones, and will serve as a source of material from which

* van Emden, I. J. H. (1940). *Arch. Theecult.* 14(1): 16-25.

new mother trees can be selected. The chief difficulty encountered in the establishment of seed gardens from clonal material is to provide a suitable combination of clones which will ensure adequate pollination and from which desirable progeny will be obtained. This is best determined by small scale experiments involving artificial hybridisation.

QUALITY TESTING

Much still needs to be done in this field of work, but the results obtained so far are encouraging. A micro-method of manufacture has been evolved, suitable for the produce of a single bush or a clone in a small scale testing experiment. *It is already established that pronounced clonal differences in quality exist*, particularly as regards flavour and aroma. In van Emden's paper, five clones are listed which are considered to be of outstanding merit in this connection.

CONCLUSION

As a rule in the selection of a perennial crop, vegetative and generative periods can be distinguished — periods in which primary importance is attached to vegetative or to generative selection. From about 1905 to 1930, tea selection was exclusively generative, *i.e.*, it was concerned with the selection of seedlings produced by (frequently) random hybridisation. The vegetative period commenced in 1932, and is approaching its climax with the completion of the clone-testing experiments.

For the future, research procedure will tend to diverge from the *practical application* of the results of selection. The former will doubtless involve an increasing number of hybridisation studies, while the latter will remain in the vegetative field and will lead to the use of budded clones for estate purposes. Since expansion is only possible to a limited degree, the use of budded clones must largely be restricted to the improvement of existing estates. As mentioned above, the best method for this will be complete and gradual replanting with budded stumps. Using properly tested clones, very uniform fields will result and an increasing degree of standardisation of factory procedure, with a corresponding improvement in quality, will become possible.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 19-12-40

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held at the Ceylon Chamber of Commerce Rooms, Colombo, on Thursday, December 19th, 1940, at 2-30 p.m.

Present.—Mr. James Forbes (Chairman), the Hon'ble the Financial Secretary (Mr. H. J. Huxham), the Acting Director of Agriculture (Mr. M. Crawford), The Chairman, Ceylon Estates Proprietary Association (Mr. C. H. Bois), Mr. R. G. Coombe, Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs. J. C. Kelly, J. D. Hoare, T. B. Panabokke, Adigar, W. H. Gourlay and Dr. R. V. Norris (Director and Secretary, T.R.I.)

1. The Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board held on the 24th October, 1940, were confirmed.

A letter from Mr. R. C. Scott, Chairman, Planters' Association of Ceylon regretting inability to be present at the meeting was read. The Board wished Mr. Scott a speedy recovery from his accident.

3. T. R. I. BOARD AND COMMITTEES

Reported that Major Oldfield and Mr. Kelly had been renominated by the Ceylon Estates Proprietary Association as their representatives on the Board for a further period of three years as from 1st January, 1941.

Reported that Messrs. R. G. Coombe and J. D. Hoare had been renominated by the Planters' Association of Ceylon as their representatives on the Board for a further period of three years as from 1st January, 1941, and that Mr. G. K. Newton had been nominated by the same body to act for Mr. James Forbes during his absence on leave.

Chairmanship.—Mr. Forbes said this matter would be taken up at a later stage of the Meeting.

4. FINANCE

(i). *T. R. I. Accounts to 30th November, 1940.*—The Chairman apologised for the omission of the rainfall figures in the estate statement. The accounts were accepted on the motion of Mr. Kelly seconded by Mr. Coombe.

(ii). *Investments.*—The Board accepted the recommendation of the Finance Sub-Committee that a sum of approximately Rs. 40,000 should be invested. After discussion it was decided to purchase Ceylon Savings Certificates to the nominal value of Rs. 20,000 and to invest the balance in the new 3 per cent Ceylon War Loan which would be redeemable in about 15 years.

It was noted the whole of the sum required for the 1941 repayments of the Government Loan to the Institute had already been placed on fixed deposit.

(iii). *T. R. I. Estimates for 1941.*—The Chairman said the estimates had been examined by the Finance Sub-Committee and recommended for approval without change.

The Estate Estimates had previously been scrutinized by the Estate and Experimental Sub-Committee.

Commenting on the revised estimate of receipts and expenditure for 1940, the Chairman pointed out that receipts were higher and expenditure lower than foreseen when the original estimates were framed. In consequence there was likely to be a surplus on revenue account of about Rs. 62,000 instead of Rs. 43,000.

For the year 1941 a surplus on revenue account of about Rs. 39,000 was anticipated. The Cess for 1941 had been calculated on $7\frac{1}{2}$ per cent restriction but it was likely there would be a further increase in the export quota.

With reference to Estate capital expenditure in 1940 it would not be possible to complete work on the new lines and maternity ward before December 31st, and the unexpended sum estimated at about Rs. 6,850 would have to be carried forward to 1941 accounts. A separate estimate would also be sumbitted at a later date for the necessary structural repairs to the Empire Drier. At present agreement had not been reached as to what should be done to this machine.

Estate Working Account.—The Chairman said the acreage figures had to be amended, fuel reserves being increased by 6 acres and waste land reduced by a similar figure.

The Board approved that General Charges should be distributed in the proportion of 90 per cent to Working Account and 10 per cent to Capital Account, the position in regard to new clearings being the same as in 1940.

Estate Capital Account.—The Chairman explained that the question of water sanitation for estate lines and other buildings was under examination but full details were not yet available. A separate estimate for this work would be submitted later.

Discussion took place in regard to the construction of the quarters for the Assistant Estate Clerk, with particular reference to the necessity or otherwise of the use of steel. It was ultimately decided that if difficulty were experienced in obtaining the necessary steel work, a revised estimate based on the use of alternative materials would be submitted.

After the Chairman had given details of expenditure under other heads the Estate Estimates for 1941 were approved on the motion of Adigar T. B. Panabokke seconded by Major Oldfield

Estate Working Account Rs. 116,797 or 63.14 cents per lb

Estate Capital Account Rs. 16,799 or 9.09 cents per lb

The Board also approved that the unexpended balance of the 1940 votes for new lines and the maternity home should be carried forward to 1941, the actual sum involved being reported to the Board at the next Meeting.

Major Oldfield referred to the valuable assistance rendered by the Estate and Experimental Sub-Committee in their scrutiny of the draft estimates.

Research Estimates.—The Director gave details of expenditure under various heads.

The Estimates, Rs. 252,413 on Revenue Account and Rs. 2,250 on Capital Account, were approved on the proposal of Mr. R. G. Coombe seconded by Mr. C. H. Bois.

In regard to the estimates generally, the Chairman said efforts were being made to distribute expenditure on the upkeep of buildings and machinery as evenly as possible over successive years. So far as the factory and machinery were concerned Mr. Whitehead was being consulted.

5. ST. COOMBS ESTATE

(i). *The Visiting Agent's Report dated 5th November* which had been reviewed by the Estate and Experimental Sub-Committee

was considered together with item 6, *the Minutes of the Meeting of the Estate and Experimental Sub-Committee held on the 25th November.*

In reply to Major Oldfield, the Chairman said that the necessary training for the Withering K.P. could be given at St. Coombs with assistance from Mr. Lamb.

In reply to Mr. Coombe, the Director said he would obtain figures of working costs of the two driers and the details of the distribution of working between these.

The Visiting Agent's report and the Minutes of the Estate and Experimental Sub-Committee were recorded.

(ii). The Board decided to tender approximately 80 per cent of St. Coombs crop to Government in 1941.

(iii). *Rice.*—The Board accepted the recommendation of the Finance Sub-Committee that a contract for the whole of the rice required in 1941 should be made. In this connection the Chairman said the question of the issue price of rice was still under discussion. The Director reported that approximately three months' stock was maintained.

6. SENIOR SCIENTIFIC STAFF

(i). *Director.*—Reported that the Director had returned from leave on the 1st December having utilised 3 months and 23 days only of the six months due to him. In this period, moreover, the Director had utilised part of his leave in visits to the Tocklai and U.P.A.S.I. Tea Experimental Stations and tea estates in Assam, Darjeeling and S. India.

Dr. Norris then gave a short account of his visit to the tea areas in N.E. and S. India In particular he referred to discussions held with Mr Carpenter, the Chief Scientific Officer Tocklai, on the lines on which the joint research on the chemistry of tea should proceed. A preliminary report on Dr. Bradfield's work had been received and a joint note prepared by Mr. Carpenter and himself had been forwarded to the Indian Tea Association and a copy to the Ceylon Association in London. In this they had stressed the necessity that work should not be confined to made tea but that green leaf should also be examined as this would be of more immediate assistance to the work on manufacture in progress in India and Ceylon. There had not been time yet for a reply to be received to this note and meantime he thought no further action was required.

(ii). *Agricultural Chemist (Dr. T. Eden).*

(a). Reported that when Dr. Eden proceeded on leave early in 1941, the Director would take over Dr. Eden's Department and Dr. Gadd would supervise the work of the Plant Physiologist's Department which had been under Dr. Eden during Dr. Tubbs' absence on military service. No financial implications arose.

(b). Dr. Eden was appointed to the Selection Grade with effect from 1st January, 1941.

(iii). *Plant Physiologist (Dr. F. R. Tubbs).*—The Chairman said the Board would be glad to know that Dr. Tubbs had fully recovered from his wounds and was now in England with his regiment.

(iv). *Entomologist.*—The Chairman said Mr. King had previously been granted permission to volunteer for service overseas and he had recently submitted his name for the Royal Air Force Volunteer Reserve. The matter was not decided yet but it was quite likely Mr. King would be leaving the Island.

7. JUNIOR SCIENTIFIC STAFF

Small-Holdings Officer, Gampola.—Reported that Mr. Illankoon had been mobilised since August with the C.L.I. and it seemed likely that, unless reasons of health intervened, such mobilisation would continue.

The Director was asked to ascertain whether it would be possible for Mr. Illankoon to be relieved from time to time for short periods so that his work could receive some attention.

Failing this the Director said he might be able to second an assistant from another Department as a temporary measure.

It was decided the Director should report on the position at the next meeting.

8. RULES OF THE BOARD

The Board confirmed the amendment of Rule 19(G) passed at the last meeting. Rule 19(G) will therefore now read:—

> "That a monthly statement of receipts and expenditure under the sanctioned heads shall be prepared by the Director and forwarded to the Chairman not later than the end of the next following month, and that before each

Board Meeting a statement showing the financial position as disclosed in the last prepared monthly statement shall be circulated to all Members of the Board."

9. RESEARCH ON THE CHEMISTRY OF TEA

The Chairman said in view of the report made by the Director under Item 7(i), it was not necessary to deal further with this question

10. CONFERENCE

It was decided that it would not be practicable to hold a Conference in 1941 owing to the depletion of staff and the difficulty which would arise in regard to attendance under present war conditions.

11. ANY OTHER BUSINESS

Reported that a successful Small-Holdings Competition had just been concluded in the Southern Province.

12. CHAIRMANSHIP OF THE BOARD

The Chairman said that for domestic and other reasons he would shortly be proceeding on leave and it would be necessary therefore for the Board to elect a new Chairman. In this connection he mentioned that Mr. Newton had been nominated by the Planters' Association to take his place on the Board during his absence and he thought that at a later date when Mr. Newton had gained experience of the work of the Board he would make an excellent Chairman, After considerable discussion it emerged that Mr. T. B. Panabokke, Adigar, would be willing to take on the Chairmanship as a temporary measure Mr. Forbes then proposed from the Chair that Mr. T. B. Panabokke, Adigar, be elected Chairman of the Board with effect from 1st January, 1941. This was carried with acclamation.

Mr. Panabokke in acknowledging his election said he regarded this as a great honour. He trusted, however, that his nomination would be for a limited period only after which Mr. Newton or some other member of the Board would relieve him.

Mr. Forbes then said:—

"Before we part I would like to place on record in the Minutes of the Board an expression of my appreciation of the services rendered to the Institute by Dr. Norris and all the members of his staff, and in that I include both Senior and Junior Staff of both the Research and Estate sides. To that I would like to add an expression of my personal thanks to all of them for the loyal and willing service they have given me.

"Next I would like to thank the Planters' Association of Ceylon and their two Senior Officers, Messrs. Turner and Bisset, for all the assistance they gave me when I first undertook this work nearly seven years ago.

"Great credit is also due to the two Visiting Agents, with whom I have been associated, Messrs. Ferguson and Tonks, by whose valuable advice coupled with capable management, our estate is now one of the best in the Island.

"Brief reference must be made to our Auditors whose lengthy reports have always been of much value and assistance and to successive Financial Secretaries. I would especially refer to Mr. Huxham's help in the reorganisation of our accounts.

"And then I come to the Board. In these seven years there have been many changes in the personnel of the Board but I have always found that each and every member has given his best possible service to the Institute and I would like to thank you all for the invaluable help you have given me.

"If I may close on a personal note I would say that though the duties of Chairman have been at times onerous and not always free from anxiety, I have thoroughly enjoyed myself and have deemed it both a pleasure and an honour to have been privileged to work with such a splendid body of people."

Mr. Bois said that though he had not been a member of the Board for a very long time, as the Chairman of the Ceylon Estates Proprietary Association and on his own behalf he would like to express their deep gratitude to Mr. Forbes for all he had done in the interests of the Board, the Tea Industry and the Island. Mr. Forbes had spent an immense amount of time on this work, he had every detail at his fingers' tips and his conduct of meetings had been a wonderful example of how meetings should be run. He felt sure the Board would wish to place on record an expression of their great appreciation—(Applause).

Mr. R. G. Coombe said as one of the oldest members of the Board and a former Chairman he wished to associate himself with all Mr. Bois had said. He had felt it a privilege to work with Mr. Forbes both on the Board and many other public bodies. He wished Mr. Forbes a very pleasant leave and hoped it would be possible to welcome him back at a later date for more useful service.

Dr. Norris said he would like, on behalf both of himself and all the staff of the Institute to be allowed to say how much they all regretted Mr. Forbes' departure. It had been a pleasure to them

all to work under Mr. Forbes who has taken the greatest interest in their work and at all times given them in unstinted measure his confidence and support.

Mr. Forbes acknowledged with great appreciation the references to his work as Chairman and after wishing all present the compliments of the season, declared the meeting closed.

ROLAND V. NORRIS,
Secretary.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. M. Y. Hemachandra & Co., Forwarding Agents. *Carriage should be pre-paid.*

Visitors' Days.—The *second* and *last* Wednesdays in each month have been set aside as Visitors' Days at St. Coombs Estate, and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

RULES FOR THE OCCUPATION OF ST. COOMBS GUEST HOUSE

(1). The Guest House is normally intended for the use of persons visiting the Institute and St. Coombs Estate on business. Children can in no circumstances be accommodated.

(2). Permission to occupy a room for the night must be obtained from the Director in writing and, unless sufficient notice be given, accommodation cannot be guaranteed. Two double rooms are available for the use of visitors accompanied by their wives.

(3). All visitors must sign the Visitors' Book on arrival.

(4). A bedroom may not be occupied for more than one night if required by another visitor. This shall not apply to Members of the Board or of Committees meeting at St. Coombs who shall also be entitled to priority in the allocation of accommodation when on official business.

(5). Complaints or suggestions shall be entered in the book provided for the purpose and not made to the Guest House Staff. All payments due for services rendered shall be made in *cash* to the steward-in-charge and a receipt obtained from him on the official form. The scale of approved charges is posted in the building. The steward is forbidden to give credit or to accept cheques.

(7). Liquor is supplied for consumption *in the premises only*.

(8). The Institute accepts no responsibility for cash, jewellery or other valuables of any kind left in the Guest House.

(9) All breakages will be charged for at cost price.

ROLAND V. NORRIS,
Director.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon:—

(1) Mr. R. G. Coombe

(2) Mr. James Forbes (on leave), Mr. G. K. Newton (acting).

(3) Mr. J. D. Hoare

(B) Representing the Ceylon Estates Proprietary Association:—

(4) Major J. W. Oldfield, C.M.G., O.B.E., M.C.

(5) Mr. I. L. Cameron (on leave) Mr. W. H. Gourlay (acting)

(6) Mr. J. C. Kelly

(C) Representing the Low-Country Products' Association:—

(7) Mr. S. F. H. Perera

(D) Representing the Small-Holders:—

(8) Mr. T. B. Panabokke, First Adigar (Chairman)

(E) Ex-Officio Members:—

(9) The Hon. the Financial Secretary

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

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The publications of the Tea Research Institute will be sent, free of charge, to Superintendents of Ceylon tea estates, over 10 acres in extent, and to Estate Agencies dealing with Ceylon tea, if they register their names and addresses with *the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle.*

Other persons can obtain the publications of the Institute on application to the Director, the subscription being Rupees fifteen per annum for persons resident in Ceylon or India, and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4*s*. In the case of Indian cheques four annas should be added to cover commission.